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A Comparative Analysis of Regulations for the Geologic Storage of Carbon Dioxide

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Abstract

This paper presents a summary of the main international and national regulations for geologic storage of carbon dioxide. The international group includes the EU Directives, London Convention, and OSPAR. For the national regulations, three countries were covered in this study: United States, Canada, and Australia. In addition to these regulations, a group of guidelines and best practice manuals were also included in this study. As discussion, although this paper recognizes that current legislations have contributed for the regulation of this technology, it is still necessary the development of new rules in other regions. Industry will not invest in large CCS plants without such regulations because of high CCS costs and large financial risks related to CCS.

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1. Introduction

In recent years, several national and international regulations have been created and/or adapted with the purpose of boosting the deployment of CCS technologies and in particular, the geologic storage. Since CCS is a relatively new technology, it would need, in some cases, only an adaptation of current legislation such as those dealing with capture and transportation, but issues dealing with injection, closure and post-closure would probably need the creation of new frameworks. Also the industry, academy, NGOs, and think tanks, pursuing a deployment of CCS, have published guidelines, best practice manuals, and standards.

This study summarises the most significant regulations at the international and national jurisdictions as well as guidelines and best practice manuals for the geologic storage of CO₂. It starts with the EU CCS Directives, London

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Protocol and OSPAR Convention, followed by national regulations in United States, Canada, and Australia. Finally this study cites some of the most common guidelines for the geologic storage of CO₂.

2. International Regulations

2.1. EU Directives

This CCS Directive (2009/31/EC), along with other modified legal acts, constitutes a comprehensive regime for the use of CCS technology, valid in all EU Member States. It covers operation, closure and post-closure obligations, CO₂ acceptance criteria, monitoring and reporting obligations, inspections, measures in case of irregularities and/or leakage and provision of financial security. It also establishes environmental rules and liability requirements for the geological storage of CO₂. This directive should be transposed into Member States' national laws by June 2011 [1]

The controversial topic of liability has been the focus of much discussion. Responsibility for closed storage sites is usually transferred to the state after 20 years if certain requirements are met, however, Member States are able to set longer periods. By March 2015, the Commission should receive reports on progress and success of the Directive, including whether permanent containment of CO₂ has been sufficiently demonstrated to prevent and reduce negative effects to human health and the environment.

The approach taken to the composition of the CO₂ stream (Article 12) is based on OSPAR and in the London Protocol, and comprises qualitative criteria: it prohibits on adding any substances for the purposes of disposal, and a requirement that the concentrations of any contaminants from the source or capture process must not be such as to jeopardize the security of the transport infrastructure or storage site [2]

The scope of this Directive mandate that all new plants, with a rated electrical output of 300 megawatts more, are permitted if they comply with the CCS ready concept, however it is not applicable to research projects with annual emissions below 100,000 tonnes. Noticeably in this Directive, emissions captured and stored are recognised as not emitted under the Emissions Trade System (ETS) [3]. Some articles in this Directive amend others in order to include CCS in their scope (See Figure 1):

- Article 31 - Directive 85/337/EEC requires EIA studies for pipelines, facilities and storage sites for CO₂
- Article 32 - Directive 2000/60/EC allows CO₂ storage in saline aquifers
- Article 33 - Directive 2001/80/EC requires CCS readiness for plants with a capacity of 300 MW or more
- Article 34 - Directive 2004/35/EC allows environmental liabilities for CO₂ storage sites
- Article 35 - Directive 2006/12/EC where CO₂ is not considered as "waste"
- Article 36 - Regulation (EC) No 1013/2006 for transporting CO₂ through ships
- Article 37 - Directive 2008/01/EC where CO₂ capture is part of Integrated Pollution Prevention & Control.

The Commission has been working in the final guidance documents, for this Directive, which are expected to be published in October 2010. They are:

- Guidance 1: CO₂ Storage Life Cycle Risk Management Framework
- Guidance 2: Site Characterisation, CO₂ Stream Composition, Monitoring and Corrective Measures
- Guidance 3: Criteria for Transfer of Responsibility to the Competent Authority
- Guidance 4: Financial Security and Financial Contribution

2.2. London Protocol

On November 2006 the Contracting Parties to the London Protocol adopted amendments to Annex 1 by adding 'CO₂ streams from CO₂ capture processes' to the list of certain substances allowed for disposal. The amendments entered into force on February 2007 and they state that CO₂ streams may only be considered for dumping, if: disposal is into a sub-seabed geological formation; they consist overwhelmingly of CO₂; and no wastes or other matter are added for the purpose of disposing of them. On October 2009, the London Protocol had an amendment to its Article 6, solving the issue of transboundary movement of CO₂ streams to other countries [4, 5]

The Scientific Group of the London Protocol produced two sets of detailed guidelines on geological storage of CO₂: The Risk Assessment and Management Framework for CO₂ Sequestration in Sub-seabed geological Structure

(known as the RAMF) [6], and the Specific Guidelines for Assessment of CO₂ Streams for Disposal into Sub-seabed Geological Formation [7]

The RAMF is based in the 2006 IPCC Guidelines [8]. It places two kinds of monitoring: for measuring performance within the geology and for monitoring when leakage is suspected. Also following the 2006 IPCC Guidelines, the RAMF recognizes that each storage site is different and consequently site characterization and risk assessment should be on a site-by-site basis.

The London Guideline is a standardized version of the RAMF and includes requirement for impact hypothesis, remediation and site closure plan with a post-closure monitoring. It also contains further definition of the CO₂ stream which clarifies what substances can be added to assist CCS for monitoring. Permits should be reviewed at regular intervals and should take into account any changes identified from monitoring and updated risk assessments.

2.3. OSPAR

In 2007 the Contracting Parties to the OSPAR Convention adopted amendments to the Annexes to allow the storage of CO₂ in sub-seabed geological formations [9]. They also included the OSPAR Guidelines for Risk Assessment and Management [10], and adopted a Decision to prohibit placement of CO₂ into the water-column of the sea [11]. The OSPAR Guideline is mandatory when issuing permits for geological storage of CO₂. This is different to London Protocol where similar guidelines are for guidance only.

OSPAR is considered more restrictive than London Protocol. It prohibits onshore CO₂ going to a storage site via an offshore petroleum-related platform and transport by ship for offshore injection. Transport via a pipeline from land that to a storage site that did not require use of a platform placed in the maritime area for oil and gas exploration was permissible. The principles established for CCS in London were repeated in OSPAR, but refinements included the addition of an “impact hypothesis” in the risk characterization, providing more information on monitoring requirements [12]. OSPAR Decision suggest that monitoring may cease when confidence exist in the security of the CO₂ storage. The OSPAR Decision also included the requirement for reporting, including post-closure reports, and a template in the Appendix 1.

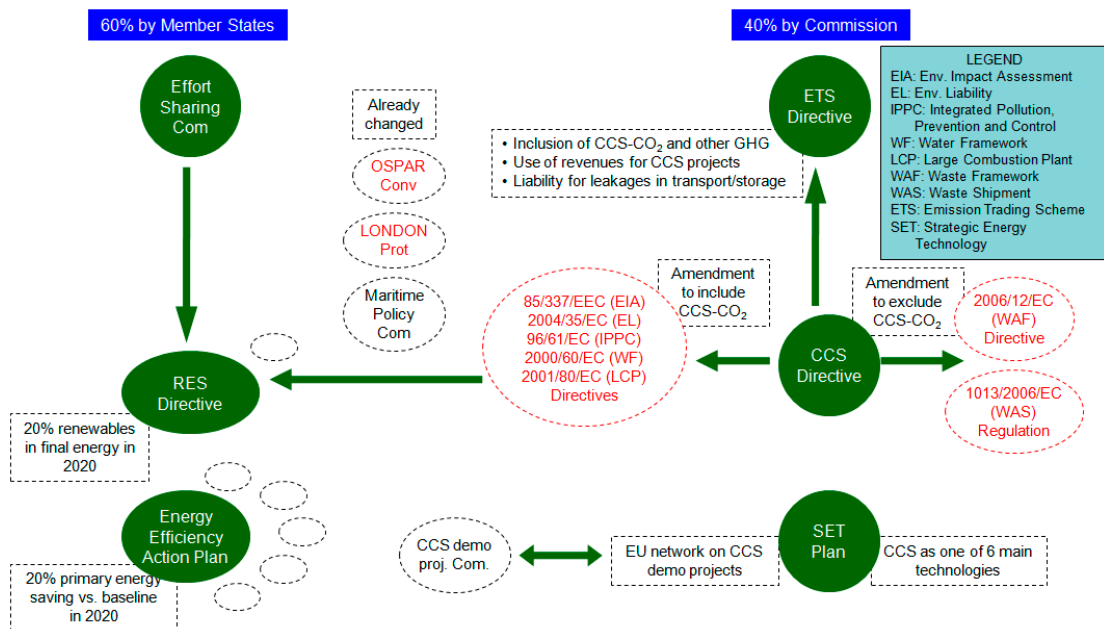


Figure 1. EU Directives related to CCS. Source: adapted from [13]

As part of the international regulations, a number of organizations have been created for legislation-related issues. For instance, the IEA in 2004 launched a project to inform and engage regulators and other experts on various legal aspects of CCS, which included in 2008 the introduction of the International CCS Regulators' Network [14]. Also the IEA, in agreement with the Faculty of Laws at University College London created the Carbon Capture Legal Programme (CCLP), [15].

3. National Regulations

3.1. United States

Different laws and regulations related to the geologic storage of CO₂ have been discussed both at the Congress and the Senate of the United States. A summary of the most important regulations is given in Table 1.

At federal level, the EPA-UIC proposed rule applies to owners or operators of wells which inject CO₂ into the subsurface for the purpose of long-term storage. This proposal is based on the existing UIC regulatory framework, which provides for the protection of underground sources of drinking water. In order to address the unique nature of CO₂ injection for geological sequestration, a new category of injection well for compressed CO₂ was created, covering the entire process of CO₂ storage from site characterisation to post-injection site care and closure. This rule does not regulate areas of capture and transport, nor does it apply to CO₂ injection for the purposes of EOR. The EPA-UIC proposed rule defines a timescale of 50 years for post-injection site care or monitoring [16]

The EPA's proposal is to create a new category of well (Class VI) with new federal requirements which include site characterisation, well construction and operating requirements, mechanical integrity, monitoring requirements, well plugging post-injection, site closure requirements, and financial responsibility: operators must demonstrate and maintain financial responsibility for activities related to closing and remediation. Issues not covered are: underground property rights and long-term liability for environmental impacts other than ground water contamination matters [17]

Other regulations related to the geological storage include the American Clean Energy & Security (ACES) Act, also known as 'Waxman-Markey Act' [18]. The subtitle B of this Act regulates CO₂ capture and storage activities. In this Act, the Administrator must establish a coordinated approach to certifying and permitting geologic sequestration. Once this Act is passed by the Senate and in a period of two years, the Administrator must introduce regulations to protect health and the environment by reducing the risk of leakage. These regulations may include: a process to obtain certification, requirements for monitoring, requirements for record keeping and reporting, public participation in the certification process, and sharing of data between states, Indian tribes and the EPA.

In September 2007, the Interstate Oil and Gas Compact Commission (IOGCC) Task Force on Carbon Capture and Geologic Storage released its guidelines in an effort to implement CCS technologies among their member states. In general, this guideline is based on existing EOR, acid gas injection and natural gas storage expertise. It also includes recommendations for operational standards and closure phase [19]

At State level, several frameworks have been discussed. Among the most important ones related to the GSC:

- Indiana - SB.211 (2010)
- Kansas - HB 2419 (2007)
- Kentucky - HB.213 (2010) and HB.491 (2010)
- Louisiana - HB 661 (2009)
- Michigan - SB.775 (2209)
- Montana - SB 498 (2009)
- North Dakota - S 2095 (2009)
- Oklahoma - SB 610 (2009)
- Texas - SB 1387 (2009)
- Utah - SB 202 (2008)
- Virginia - SB.247 (2010)
- Washington - SB 6001 (2007)
- West Virginia - HB 2860 (2009)
- Wyoming - HB 90 (2008)

Table 1. Summary of American regulations related to geologic storage of CO₂ (GSC)

Legislation	Description
EPA UIC Rule	Federal requirements under the Underground Injection Control (UIC) Program for CO ₂ Geological Storage
HR 2454 (2009) - American Clean Energy & Security Act 'Waxman-Markey Act'	Title I, Subtitle B on CCS gives responsibility to the EPA administrator, in consultation with the Secretary of Energy and the Secretary of Interior, for reporting to the Congress on key legal issues and barriers to the acceleration of commercial viability of CCS
HR 1689 (2009) - CCS Early Deployment Act 'Boucher Bill'	It was incorporated within HR 2454. Provides for a referendum of relevant industries to incorporate a CCS Research Body to raise and distribute funds to CCS programmes
S.1462 (2009) - American Clean Energy Leadership Act	Regulatory framework for CCS as well as financial assistance for demonstration programmes. Under this Bill, the DOE will be responsible for speeding-up CCS demonstration programmes
S.1013 (2009) – Department of Energy CCS Program Amendments Act	It has been partly incorporated within S.1462. This Bill will amend the Energy Policy Act 2005 and also takes into account safety and environmental aspects of CCS operations
S.1502 (2009) - Carbon Storage Stewardship Trust Fund	Long-term Federal stewardship of storage sites accompanied by a trust fund to meet costs and post-transfer liabilities
S.2744 (2009) - Carbon Dioxide Capture Technology Act	This Bill will provide scientists and researchers with financial awards for developing technology for 'separation of carbon dioxide from dilute sources'
American Power Act (2010) – 'Kerry-Lieberman Bill' (DRAFT)	This Bill establishes a national cap-and-trade system, introduces a strategy for the development of CCS as well as a number of financial incentives
S.3589/S.3591 (2010) S.3590 (2010)	These bills provide financial incentives and a regulatory framework to facilitate the development and early deployment of carbon capture and sequestration technologies. There are also provisions to regulate the long-term stewardship of the stored CO ₂

3.2. Canada

The Canadian Federal Government does not have regulations dealing with CCS nor geologic storage of CO₂. Provinces, on the other hand, have a vast experience with oil and gas, particularly with enhanced oil recovery EOR-CO₂ and injection of acid gases in Alberta, British Columbia and Saskatchewan. These provincial regulatory frameworks may be expanded to cover the permanent storage and the post-abandonment stage of CO₂ storage operations, including monitoring and remediation. Issues that need to be considered include financial incentives, liabilities, ownership, and access rights. It is expected that the federal government adopt a similar scheme as the US-ACES Act

Recently the federal government amended the Canadian Environmental Protection Act (CEPA-1999) to designate GHGs as "toxic" substances (Schedule 1-substance #74) [20]. Consequently, under CEPA, emitted CO₂ may be regulated similar to other airborne emissions through federal legislation. Also, under the Federal Transportation of Dangerous Goods Act 1992 (TDGA), CO₂ is considered as a "dangerous good" and, as a result, a series of notification, manifesting and safety compliance obligations may apply [21].

In January 2008, the Federal Ministry of Natural Resources together with the Ministry of Energy of Alberta released the ecoEnergy Canada's Fossil Energy Future [22]. In March same year, the Federal Ministry of Environment launched two documents through ecoAction: Taking Action to Fight Climate Change, and the Regulatory Framework for Industrial Greenhouse Gas Emissions [23, 24]. Also, as part of the technology demonstration and early deployment incentives, the federal government released the Canada's Action Plan which proposes investment of C\$650 million in large-scale CCS projects.

In the province of Alberta, there are several regulations on disposal of acid gases (H₂S, SO₂) in saline aquifers since this activity has been common since 1989 [25, 26]. These regulations demand that applicants must meet regulatory requirements, including selection of reservoir and reservoir property characterisation. Licensees are subject to continuing responsibility for the management and control of the well and they must report financial information. If

the licensee's liabilities exceed its assets, the licensee must place a security deposit for the difference. All licensees must pay into a general fund, which is used to fund the abandonment stage. Also in Alberta, in June 2009, was released the Carbon Capture and Storage Funding Act 2009 followed by the CCS Funding Regulation in April 2010 [27, 28]. This Act and Regulation allocates two billion dollars of funding for CCS development.

In the province of Saskatchewan, in December 2009, was introduced the Bill-126 - Management and Reduction of GHGs [29]. The regulation of this bill is currently under discussion. This Bill creates a Fund and a Foundation for funding CCS projects, geological storage included. Also it is notorious in this province the work between the Canadian Standard Association (CSA) with IPAC-CO₂ to develop the World's first standard for the geologic storage of CO₂, which is expected to be presented in 2012.

3.3. Australia

At Federal level, the Commonwealth Offshore Petroleum Act 2006 was amended in 2008 to establish a regulatory framework that encompasses both petroleum and GHGs activities in offshore waters [30]. Interestingly, this Act uses the word 'greenhouse gases' instead of only CO₂ which gives flexibility for future amendments to include other GHGs as disposal, but this would be possible only if the London Convention is amended to permit the storage of other GHGs. Also this Act includes provisions which allocate the long-term liability for storage sites to the Commonwealth after a 15 year assurance period. The Minister will only give permission if post injection monitoring shows that the stored substance is behaving as predicted and does not pose a significant risk to human health or the environment. A closing certificate requires the pre-payment for an approved longer-term monitoring program.

In 2009, the Minister for Resources and Energy presented a consultation draft of the Petroleum (Submerged Lands) (Management of Environment) Amendment Regulations [31]. This regulation includes plans for monitoring and verification, risk management, details for an Environment Management Plan, fees for applications, renewals and transfers of the GHG storage tenures. Also in 2009, the Environment Protection and Heritage Council (EPHC) released its Environmental Guidelines for Carbon Dioxide Capture and Geological Storage [32]. This guideline was developed to assist regulators, proponents and the public to understand the application of existing environmental laws, and to promote a comprehensive and nationally consistent approach to environmental assessments of CCS projects. As guideline, it does not seek to impose a regulatory or administrative burden in addition to existing State government requirements, but it is intended to build on the CO₂ Capture and Geological Storage [33].

At state level, Victoria released its Offshore Petroleum and Greenhouse Gas Storage Act 2010, which complements the Greenhouse Gas Geological Sequestration Act 2008 and its Regulations [34, 35, 36]. In Queensland, the GHG Storage Act 2009 was passed by Parliament in February 2009 and its Regulations in April 2010 [37, 38]. By this Act and Regulation, any proposed GHG storage activities can be subjected to EIA. In South Australia, the Petroleum Act 2000 focus uses the term 'storage' instead of 'disposal', leaving not clear provisions in relation to what happens to injected CO₂ when the injection ends, including liability issues [39]. Finally, in Western Australia due to the Gorgon Project, both transport and disposal is facilitated by the Barrow Island Act 2003. Interestingly, Section 14 of this Act gives the ownership of underground geological formations in the Crown [40]

Table 2. Summary of Australian regulations related to geologic storage of CO₂ (GSC)

Legislation	Description
Commonwealth Offshore Petroleum Amendment (GHG Storage) Act and Regulations	This act establishes a system of offshore titles for carbon dioxide storage in offshore waters, including a framework for the transfer of long-term liability to the Government at the end of a 'closure assurance period'
Queensland GHG Storage Act and Regulations	Act concerning storage aspects of CCS activities, modelled on the existing oil and gas regulation. It requires two types of tenures: exploration permits as well as injection and storage leases.
South Australia Petroleum and Geothermal Energy Act 2000	This Act regulates the exploration and the recovery or commercial utilisation of petroleum
Victoria GHG Geological Sequestration Act and Regulations	This Act regulates CCS storage activities in onshore Victoria by creating a permitting system for the access to geological storage formations.
Victoria Offshore Petroleum and GHG Storage Act 2010	This Act introduces a new regime for the exploration and operation of GHG storage sites offshore.
Western Australia Barrow Island Act 2003	This Act establishes permitting procedures for CO ₂ storage operations at Barrow Island's Gorgon project

4. Guidelines/Best Practice Manuals

Apart of the national guidelines, Table 3 summarizes some of the most common documents in different regions of the world.

Table 3. Summary of the most common guidelines

Guideline/BPMs	Description
2006 IPCC Guidelines. Volume 2, Chapter 5	This guideline provides emission estimation guidance for the capture and transport of CO ₂ and for geological storage. No emissions estimation methods are provided for any other type of storage option such as ocean storage
WRI Guidelines for CO ₂ Capture, Transport, and Storage	It gives recommendations for the whole CCS chain. The focal point in this guideline is health and safety
DNV CO2QUALSTORE Guideline	The guideline provides a comprehensive and systematic process that covers the full lifecycle of a CO ₂ storage project, from screening and site selection to closure and transfer of responsibility
SACS/CO2STORE Best Practice Manual	This BPM is framed around a seven-stage template for site development, from initial project inception to eventual site closure
IOGCC Guidelines	This guideline gives recommendations based on EOR, acid gas injection and natural gas storage. It includes ownership, permitting, verification, monitoring, and liability

5. Discussion

Few years ago industry was reluctant to build large-scale CCS plants because there were no regulations allowing CO₂ storage. In recent years has seen a positive trend in development of legislation on this issue. Policy-makers have risen to the challenge; existing regulations have been amended to allow CCS and new regulations facilitating CCS are being put into place. Many regional initiatives have been created in recent years. Australia for instance was the first country to establish regulations for CCS in 2006, and in 2008 the EU adopted a new directive on CO₂ storage. The EU has even established funding mechanisms. Hopefully, these regulations can serve as a starting point for similar initiatives in other regions of the world.

In addition to the regulations mentioned in this paper, new ones must be established to ensure that fossil fuel power plants and factories are built with CCS. Industry will not invest in large CCS plants without such regulations because of high CCS costs and large financial risks related to CCS.

In December 2010 negotiators will meet in Cancun to discuss a new international agreement replacing the Kyoto Protocol from 2013. Already, discussions are taking place on the role of CCS in the new agreement. Ideally, CCS should be included as a tool in the protocol's emission reduction mechanisms. When Kyoto was agreed, CCS was in its early beginnings and was not included in the CDM or JI mechanisms. Consequently, Kyoto gives no incentives for promoting CCS. Whether or not to include CCS in the emission reduction mechanisms is an issue of intense debates. The argument for including CCS in mechanisms like CDM is that CCS has a large potential for CO₂ emission reductions, but some negotiators still question the safety of CO₂ storage.

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